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Review

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Cross-Disciplinary Rapid Scoping Review of Structural Racial and Caste Discrimination Associated with Population Health Disparities in the 21st Century

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Abstract: A cross-disciplinary rapid scoping review was carried out, generally following the PRISMA-SCR protocol to examine historical racial and caste-based discrimination as structural determinants of health disparities in the 21st century. We selected 48 peer-reviewed full-text articles available from the University of Memphis Libraries database search, focusing on three selected case-study countries: the United States (US), Canada, and Nepal. The authors read each article, extracted highlights, and tabulated the thematic contents on structural health disparities attributed to racism or casteism. The results link historical racism/casteism to health disparities occurring in Black and African American, Native American, and other ethnic groups in the US; in Indigenous peoples and other visible minorities in Canada; and in the Dalits of Nepal, a population racialized by caste, grounded on at least four foundational theories explaining structural determinants of health disparities. The evidence from the literature indicates that genetic variations and biological differences (e.g., disease prevalence) occur within and between races/castes for various reasons (e.g., random gene mutations, geographic isolation, and endogamy). However, historical races/castes as socio-cultural constructs have no inherently exclusive basis of biological differences. Disregarding genetic discrimination based on pseudo-scientific theories, genetic testing is a valuable scientific means to achieve the better health of the populations. Epigenetic changes (e.g., weathering—the early aging of racialized women) due to the DNA methylation of genes among racialized populations are markers of intergenerational trauma due to racial/caste discrimination. Likewise, chronic stresses resulting from intergenerational racial/caste discrimination cause an "allostatic load", characterized by an imbalance of neuronal and hormonal dysfunction, leading to occurrences of chronic diseases (e.g., hypertension, diabetes, and mental health) at disproportionate rates among racialized populations. Major areas identified for reparative policy changes and interventions for eliminating the health impacts of racism/casteism include areas of issues on health disparity research, organizational structures, programs and processes, racial justice in population health, cultural trauma, equitable healthcare system, and genetic discrimination.

Keywords: racism; casteism; discrimination; health disparities; structural determinants of health disparities; socio-economic status; allostatic load

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1. Introduction

Health disparities within and between populations, across geographic regions, demographic groups such as age and sex, and due to socio-economic factors such as income, education, employment, complex indices of material and social deprivation, and environmental factors have been well documented in the peer-reviewed literature [1–4] and gray literature [5–7]. In the United States (US), the Global Burden of Disease and US Health Disparities Researchers have found that life expectancy disparities between racial–ethnic groups are widespread and persistent, and have stressed that the analysis of local-level data is vital to address the root causes of poor health and premature death among disadvantaged groups facing racial and socio-economic inequities, in order to eliminate health disparities [3]. However, much of these reports merely address "risk-factors or individual social determinants of health (SDoHs)" based on epidemiological data that show plainly the associated differences between advantaged and disadvantaged groups but do not provide concrete evidence of the root cause of these racial health inequities, which are unfair, avoidable, and unjust in present-day society [8]. Research on the relationship between structural racism and population-level health outcomes and the health impacts of policies and interventions dismantling the former has been limited [9].

Recent anthropological and ancient genome data [10,11] indicate how the populations of Europe and South Asia were formed as the admixtures of the ancient humans from Steppe Mountain and Fertile Crescent (Anatoli-Iran region) and Indigenous people, and how they created social stratification leading to racial discrimination [10] between groups of people during the transition from pastoralism to agriculture in ancient times and has since spread globally. Consequently, various regional race/caste systems have developed over time across the globe, such as Varnashram-based caste discrimination and untouchability practiced in South Asia, racism against African Americans and Native Americans in the United States, colonial racism against Indigenous Peoples in Canada, Castes of West Africa, Castas of Latin Americas [12], and other forms of inherited racial hierarchies still active in East Asia [13]. Racism, casteism, or all other descent-based social stratification systems have the same core elements: a system of dehumanization, inequality, and condemnation [12] in which a dominant group overpowers a marginalized group with the sole purpose of holding on to their resources by exercising privilege and power. In the aftermath of the early phase of the COVID-19 pandemic that left excess numbers of African American, Latinx, and Indigenous people among the sick and dying, and the anti-racism protests sparked by the murder of George Floyd, Isabel Wilkerson's book, *Caste: The Origins of Our Discontents*, brought widespread attention in the West to the concept of "caste". Initially, it was thought that caste was confined to the Indian subcontinent as a phenomenon unrelated to American racism [14]. We surmise that the consideration of historical, deep-rooted, systemic, and structural racism/casteism as the common root cause of racial/caste-based socio-economic and cultural disadvantageousness globally is essential to address the health disparities that the whole of humanity currently faces. However, the evidence of the full scope of this phenomenon of descent-based discrimination has not been consolidated. Reconciling the global literature is vital to fully understand it as a historically created global social construct.

The castes and races, thus hierarchically stratified by humans, and their associated inequalities might have common ancient roots—the transmigration and interactions among ancient cultures that spread to the East and West from Anatolia, the European Steppe, and the Mesopotamian Fertile Crescent [10]. Building on the tradition of feudal and religious hierarchies, European colonists developed the concept of racial superiority to justify the needs of European empires as they expanded across the globe [15]. The European colonists who introduced slavery to the Americas in the early 17th century buttressed the discriminatory caste hierarchy in South Asia through Anglo-Hindu Law based on colonial interpretations of Hindu scriptures and customary law then sporadically prevalent in British India in 1772 and the promulgation of Nepal's Civil Code in 1854 [16]. In the mid-19th century, books like Robert Knox's *The Races of Man* published in 1850 and Arther

de Gobineau's *Essays on Inequality of Human Races* in 1853 gave race stratifications a secular, rather than religious explanation through the use of pseudo-science [15,17,18], reinforcing the racial/caste discrimination that has been ingrained in society ever since.

Western racial discrimination and South Asian caste discrimination, with a common root of origin—the ancient mythical history of Aryan supremacy—further advanced during the colonial era from the 17th century onwards in both worlds [19]. It is well-documented that Black people and Native Americans are affected by the structural racism of colonial origin that has deep historical roots in American society [9]. Nepalese anthropologist Dor Bahadur Bista was convinced that caste discrimination, which persists in Nepal today, is an adaptation of colonial import from the 18th century [20]. Both structural racism in America and structural caste discrimination in South Asia may have produced similar health disparities created through socio-economic inequities across their populations, though reliable health data on caste discrimination for comparison are limited. Both kinds of discrimination dehumanize and marginalize an oppressed segment of the population, resulting in adverse health outcomes at the societal level through similar modes and mediating factors.

In this rapid scoping review, we explore how systems of racial/caste discrimination have led to systemic socio-economic inequities leading to population-level health disparities in the 21st century. We use the United States, Canada, and Nepal as country examples for case studies. The United States has a complex history of racism deeply rooted in its past, beginning with slavery in the 17th century, the crude and brutal racism of the antebellum period, and post-reconstruction Jim Crow laws, which segregated Black and White citizens. Despite the achievements of the Civil Rights Movement and the subsequent passage of the Civil Rights Act, racial inequities resulting in disparities in health, housing, education, criminal injustice and wealth persist. Likewise, racism against Native Americans has deep historical roots of dispossession, forced assimilation, and cultural suppression [21]. At the same time, Hispanic and Asian-American populations also face challenges of discrimination, implicit bias, and unequal opportunities [22].

In contrast to the blatant racism in the United States, Canada has handled race differently, with the historically "milder" racism built on a social order of "color blindness" transitioning to the present-day multiculturalism [15]. Browne argues that the ideologies of egalitarianism and multiculturalism in Canada, painting a picture of the state and its institutions as free from racism and other forms of discrimination, perpetuates the assumption that people are treated the same regardless of their diverse backgrounds [23]. Still, structural racism is pervasively extant in the form of implicit bias against and unequal opportunities for Indigenous people and other People of Color from various ethnic groups, who are known as visible minorities in the country. Nepal on the other hand is a particular case in the 21st century, as the country is transitioning from the crude form of historical hierarchical caste-based discrimination enforced through the Civil Code 1854 law to the more recent and progressive constitution and laws banning all forms of discrimination, in alignment, in statutory books, with the United Nations Declaration of Human Rights. However, the system of caste discrimination persists in the present real time as a form of structural casteism deeply ingrained in society, even today, mainly because of the weak enforcement of the new laws that severely lack representation from discriminated caste groups in the enforcement bodies. For all three country case studies, we aim to review the current state of health disparities associated with racism and casteism in their structural form in the 21st century.

As European powers were colonizing large swaths of the globe, colonial racism allowed wealthy and aristocratic colonizers to consolidate power in the Antebellum United States, Europe, and other colonized lands. However, the American Civil War (1861–1865) changed the course of US history, while colonial powers eventually declined worldwide, especially after World War II, which led to significant global political change as many nations embraced democracy and civil rights. Unfortunately, pseudo-scientific theories advocating falsely a biological basis for racial differences were widely known until much

later, even by the end of 20th century. Hence, our review only focuses on the consolidation of the scientific literature published in the 21st century, when a scientific consensus around health disparities associated with several socio-economic and circumstantial factors deeply rooted in structural racism/casteism disregarding pseudo-scientific theories has been in vogue, acknowledging that race and caste discrimination is immoral, despite it still persists in a systemic and structural form. Our review is a cross-disciplinary work of authors representing expertise from the fields of medical genetics encompassing population genetic variation and genetic testing, public health encompassing epidemiology and population health surveillance, applied health sciences including endocrinology, liberal arts encompassing history and African American studies, and law and public policy, which are reflected in the various parts of this paper.

Study Objectives

The main objectives of this rapid review are the following:

- To collate the literature evidence on the background realities of historical and structural racial and caste discrimination causing geographic, demographic, and socio-economic inequities and resulting in population health disparities at the societal level in the context of three case-study countries.
- To draw major themes of societal health disparities based on the theories, emerging concepts, various components, and determinants associated with structural racism and casteism.
- To consolidate a set of recommendations for reparative policy changes to help in learning from the evidence of existential realities, and unlearn and challenge the historical structural racial and caste discrimination systems that lead to population health disparities in the context of the 21st century.

2. Materials and Methods

This scoping review was completed rapidly due to two factors: a limited policy timeframe as mandated by a US Government-sponsored program, the Fulbright Fellowship, and the limited resources available to complete the task. However, we followed the PRISMA-ScR protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) as a general guideline methodology to synthesize knowledge [24], using a systematic approach to map evidence on the historical background and contemporary realities of racial and caste discrimination, their impacts on health equity, and identify central themes, theories, sources, and knowledge gaps.

This review aims to draw cross-disciplinary knowledge of systemic and structural racism/casteism and associated health disparities; we primarily used the University of Memphis Libraries' broad-based multi-disciplinary database (EBSCO database). The first author DPR, as the principal investigator (PI), in consultation with a University Librarian, drew up a set of search terms, focusing on the three case-study countries of interest, the United States, Canada, and Nepal, as per the approved program sponsored by Fulbright Canada, as follows: "SU (health (disparit* or equit* or inequi* or equal* or inequa* or disadvantag*)) AND SU (rac* or caste or ethnic* or cultur* or soci*) AND SU (discriminat* or prejudic* or bias or oppress* or marginal* or depriv*) AND SU (histori* or genetic* or anthropolog*) AND SU (Canada or (United States or US or USA) or Nepal)".

Using these search terms, our most recent search, conducted on 21 September 2023, produced 67 full-text English language articles published between 2000 and 2023 that were available through the Libraries' database. We wanted to limit our study to the literature published in the 21st century, after pseudo-scientific theories about biological basis to justify racial differences became no longer acceptable in the mainstream knowledge base. The results were then filtered to include only academic and peer-reviewed journal articles, reducing the number of articles to 53. After removing the duplicates, the number of articles came down to 32. Again, the PI looked up the PubMed database using the same search terms for articles covering health disparities that are foundational to this review work

but could have been missed from the broad database. The relevant articles were added, bringing the total number to 40. Then, the PI further looked up the list of references in the selected articles to identify any articles foundational to structural racism or casteism, adding 11 articles to the collection, and 3 manuscripts were excluded for the lack of relevance, bringing the final number of selected articles to 48. The flowchart diagram of our search strategy is presented in Figure 1.

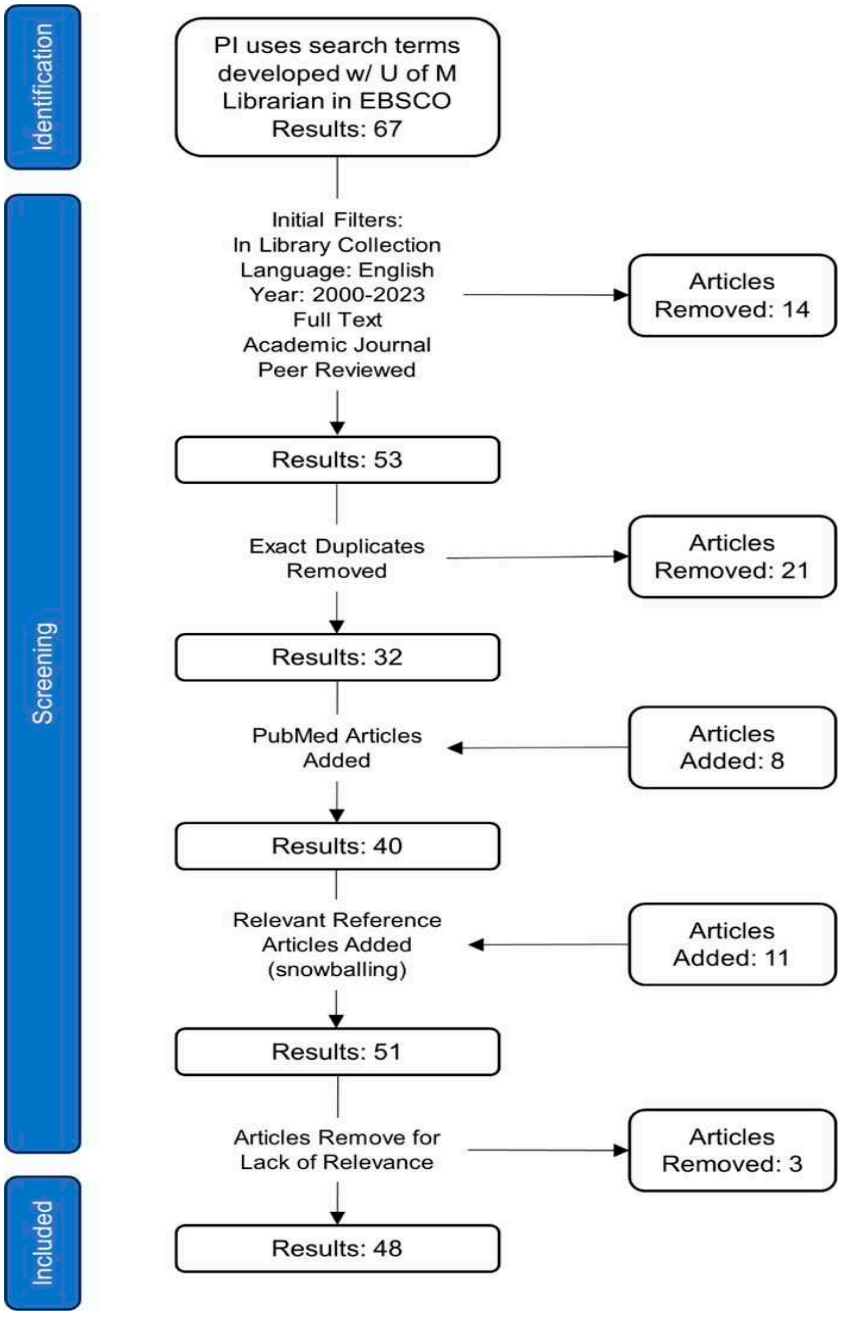

Figure 1. Flowchart of the literature search strategy.

The PI read full texts of all the selected articles and highlighted the relevant parts in the text for extraction. The research assistant (RA), BMW, extracted all the highlighted texts from the selected papers into separate documents using an Adobe Acrobat plug-in. The RA then created an Excel Worksheet to list all the selected articles, with their title, year of publication, authors, abstracts, and extracts from the highlighted parts of articles. The RA compiled the thematic items working collaboratively with the PI to summarize the

excerpts. Various major themes were drawn manually and intuitively from the extracts that were categorized and separated as thematic items into worksheet columns and directly from the articles that would be divided into the Worksheet columns. The RA put together the search flowchart and tables. The PI wrote the manuscript text for the first draft, and the RA compiled the tables and figures from the extracts. The first draft was saved in a shared Google Doc folder for every author to access and provide revision inputs and comments for improvement. All collected documents (search strategy, selected articles, protocol, worksheets, and manuscript drafts) were saved in the shared Google Doc folder(s) that were accessible to all the authors.

Other authors contributed to the writing of the manuscript, at the stage of editing with their comments and direct revisions, for the preparation of the second draft of the manuscript. All authors accessed and read the final version of the manuscript that was shared in a Google drive folder to review draft, offered insightful inputs for revision, and agreed to be co-authors for publication in an international, cross-disciplinary journal.

3. Results and Discussion

The final analytic sample included 48 articles. Table 1 presents the thematic characteristics extracted from them. Twenty-one articles dealt with health disparities across various forms of racism and casteism. Nine articles discussed health disparities impacting Black African Americans; two discussed health disparities impacting Indigenous peoples; four discussed racism-related health disparities impacting other ethnic groups; four discussed caste-based health disparities and the link between casteism, transnational casteism, and racism; and two discussed transnational casteism. Twelve articles dealt with the theoretical underpinnings of research into race and caste-based health disparities. Twelve articles dealt with genetics—with ten articles discussing genetic variations and two discussing genetic testing. Three articles dealt with epigenetic changes. Thirteen articles dealt with psychosocial stresses, allostatic load, and telomere shortening. Fifteen articles dealt with social determinants of health and structural determinants of health disparities. Eighteen articles dealt with reparative policy considerations. Thus, structural racism or casteism has been recognized as a determinant of health disparities in at least eight of the articles reviewed [9,25–31]. Other reviewed articles specifically included six reports on genetic variations, genetic testing, and epigenetics; seven reports on racial discrimination in Indigenous peoples; and three articles on intergenerational trauma. We summarize below some of the major themes that emerged from the review synthesis in the context of this research on structural racism/casteism as the root or structural determinant of health disparities in the 21st century, with unique case-study references to the United States, Canada, and South Asia, particularly Nepal.

Table 1. List of the finally selected articles and their major characteristics, with the themes extracted.

Final SN	Author(s) (Citation Year)	Studied Country/ies	Race, Ethnicity, or Caste under Study	Themes Extracted
1	Sweeting et al. (2023)	United States	African Americans; White Americans	Parental preconception adversity; Epigenetic effects on health and disease; Structural racism as a root cause; Theoretical considerations [31]
2	Hurd and Young (2023)	United States	African Americans; Latino Americans; Native Americans; White Americans	Education and clinical child and adolescent psychology; Global Diversity Equity and Inclusion (DEI); Decentering whiteness; Discrimination (overrepresentation in punitive measures); Healthcare: access, clinicians' bias, and representation among providers; Mental health; Policy implications; Research needs; Socio-economic factors [32]
3	Subica and Link (2022)	United States	African Americans; Native Americans; White Americans	Cultural/historical trauma; Cultural trauma–mechanism of affecting health disparities; Fundamental cause theory [33]

Table 1. *Cont.*

Final SN	Author(s) (Citation Year)	Studied Country/ies	Race, Ethnicity, or Caste under Study	Themes Extracted
4	Zhou and Wodtke (2019)	United States	Economic Class	Income class stratification and racial class stratification; Resource distribution—social stratification decline; Resource distribution—Socio-economic inequality [34]
5	Soled et al. (2021)	United States	African Americans; Native Americans; White Americans	Reparations; Role of medicine and pseudo-science [35]
6	Jacoby et al. (2018)	United States (Philadelphia)	African Americans; Latino Americans; White Americans	Crime; Gun violence; Present-day impacts of historical discrimination; Racial health disparities; Redlining [36]
7	Tiedt and Brown (2014)	United States	African Americans; Latino Americans; White Americans	Historical trauma and present-day discrimination as a source of chronic stress in Native Americans; Impact of stress (allostatic load) on diabetes rates [37]
8	Keyes (2009)	United States	African Americans; White Americans	Health outcome impacts—coping and resilience; Health outcome impacts—mental health extent of discrimination; Health outcome impacts—morbidity and mortality; Health outcome impacts—risk factors [38]
9	Goodman et al. (2017)	Canada (Vancouver)	Indigenous Canadians; White Canadians	Indigenous healthcare: experience and outcomes; risk factors (alcohol), race-based adverse treatment; health outcomes, stereotypes and stigma; interrelated stigma and intersectional approaches; patients' stories [39]
10	McKinney et al. (2020)	United States	African Americans; Asian and Pacific Islanders (API); Latino Americans; Native Americans; Non-Hispanic White Americans	Genetic variations—genetic testing, stigma, genetic counseling, distrust among minorities, and cultural competency training; Social cognitive theory [40]
11	Browne et al. (2016)	Canada	Indigenous Canadians; White Canadians	Indigenous healthcare—10 strategies to optimize effectiveness of healthcare; Structural violence—population and public health as a major determinant of the distribution and outcomes of social and health inequities [27]
12	Parra-Cardona et al. (2018)	United States	Mexican Americans; Non-Hispanic White Americans	Cultural adaptation; Mental health disparities—Mental health services in Latino immigrant communities [41]
13	Parkman et al. (2015)	United States	Connecticut, Michigan, Ohio, and Oregon Residents	Genetic privacy; Anti-genetic discrimination policy [42]
14	Shaw and Armin (2011)	United States	People of Color Generally; White Americans	Cultural adaptation; Physician training; Corporatization of social justice interventions [43]
15	Geronimus et al. (2010)	United States	African American Women; White American Women	Black–White health disparities; Intersection of race and gender discrimination; Accelerated biological aging in Black women [44]
16	Williams (2011)	United States	N/A	Government funding—impact on medical research; Anti-genetic discrimination police [45]
17	Lee (2009)	United States	African Americans; API; Latino Americans; Native Americans; Non-Hispanic White Americans	Use of race and ethnicity in biomedical research; Lack of a biological basis for race; Race as a proxy for socio-economic status, culture, and history [46]
18	Sankar et al. (2004)	United States	African Americans; Latino Americans; Native Americans; Non-Hispanic White Americans	Link between racial discrimination, poverty, and health disparities; Genetic research; Public health policy; Scientific racism [47]

Table 1. *Cont.*

Final SN	Author(s) (Citation Year)	Studied Country/ies	Race, Ethnicity, or Caste under Study	Themes Extracted
19	Farmer and Ferraro (2005)	United States	African Americans; White Americans	Health outcomes in Black Americans; SES—interaction of SES in racial health disparities and interaction with education is the largest [48]
20	Browne (2017)	Australia, Canada, New Zealand, United States	Indigenous People; White Americans; Australians; Canadians: and Kiwis	Indigenous healthcare in the Anglophone Western hemisphere; race-based adverse treatment; Health outcomes and stereotypes; Historical injustice; Socio-economic factors [23]
21	Thapa (2014)	Nepal	Brahman; Kshatriya (Chhetri); Dalit; Vaishya	Caste system in Nepal; Systemic discrimination; Allostatic load; Anti-Dalit discrimination; Diabetes; Cultural narratives [49]
22	Sims (2010)	United States	African American Women; White Americans	Health outcomes in Black Americans; Discrimination—impact on trust in healthcare providers [50]
23	Jackson (2008)	United States	N/A	Alternatives to race as a model of human diversity; Historical origin of racism [51]
24	Kaplan (2010)	United States	African Americans; White Americans	Race as a folk category; Black–White health disparities; Lack of a biological basis for racial categories; Impact of racism on public health outcomes [52]
25	Powell-Young and Spruill (2013)	United States	African Americans	Genetic discrimination; Minority representation among healthcare professionals; African American views of genetic testing/research [53]
26	Bloche (2004)	United States	People of Color; White Americans	Systemic racism; Ignoring race-based disparities in healthcare to justify public health policies that perpetuate race-based disparities; Ideological interference with public health policy [25]
27	Cabassa (2003)	United States	N/A	Practitioner bias in mental healthcare; Multidisciplinary approach to finding the root of mental health disparity [54]
28	Giddings (2005)	United States	People of Color; White Americans	Transcultural nursing; Cultural adaptation by healthcare professionals; Social consciousness; Gender roles in healthcare; Marginalization; Traditional constructs in nursing [55]
29	Kohrt et al. (2009)	Nepal	Brahman; Chhetri; Dalit; Janajati	Caste-based discrimination in Nepal; Mental health—stresses [56]
30	Beletsky and Grau (2010)	United States	African American; Latino Americans; Non-Hispanic White Americans	Racial profiling; Police tactics—impact on the use of substance abuse-related health services by marginalized groups; Syringe exchanges; Harm reduction; War on drugs [57]
31	Vervoort et al. (2022)	Canada	Indigenous Canadians; Non-Indigenous Canadians	Indigenous healthcare: cardiovascular healthcare, accessibility, literacy and awareness, cardiovascular health disparities; morbidity and mortality disparities [58]
32	Bailey et al. (2017)	United States	African Americans; API Americans; Latino Americans; Indigenous Americans; Non-Hispanic White Americans	Impact of structural racism on health outcomes and disparities [9]
33	Martin et al. (2022)	United States	African Americans; White Americans	Social epigenetics; DNAm: Allostatic load, impact of stress, SES, childhood and adulthood exposure to racism, and social environment; Epigenetic link to race-based health disparities; Impact of stress on the epigenome [59]

Table 1. *Cont.*

Final SN	Author(s) (Citation Year)	Studied Country/ies	Race, Ethnicity, or Caste under Study	Themes Extracted
34	Diaz et al. (2023)	United States	African Americans; Indigenous Americans; Latino Americans; Non-Hispanic White Americans	Structural and social determinants of health; Disparities in COVID-19 care/vaccination rates; Impact of racism and implicit bias on COVID-19 care [30]
35	Williams et al. (2019)	United States	African Americans; Indigenous Americans; Latino Americans; Non-Hispanic White Americans	Racism and health; Cultural racism; Structural or institutional racism; Residential racial segregation; Segregation and health; Segregation and health—epidemiological evidence [28]
36	Krieger (2005)	United States	African Americans; White Americans	Origins of racial classifications; Lack of biological basis for race; Contemporary research on US racial attitudes; Climate and race; Race and political ideology [60]
37	Martinez et al. (2021)	United States	African Americans; Indigenous Americans; Latino Americans; Non-Hispanic White Americans	Asthma and atopic dermatitis—racial disparities; Impacts of structural racism (e.g., residential segregation; socio-economic position; mass incarceration) on health outcomes, epigenome, and the microbiome; Allostatic load [29]
38	Arjunan et al. (2022)	United States	African American; API Americans; Jewish Americans; Latino Americans; Non-Hispanic White Americans	Medical racism and genetic discrimination in obstetrics; Racism and genetics; Institutional racism practiced in professional medical organizations [61]
39	Gee and Ford (2011)	United States	African Americans; API Americans; Arab Americans; Indigenous Americans; Latino Americans; Non-Hispanic White Americans	Racism—link to health disparities; Impact of structural racism (e.g., social segregation and immigration policy in Digital Spaces) on health; Intergenerational drag—generational impact of racism [26]
40	Chuang et al. (2022)	United States	African Americans; White Americans	Meta-study of racial disparities in end-of-life care; Behavioral basis for disparities; Environmental (physical and socio-cultural) basis for disparities; Provider bias [62]
41	Mehra et al. (2023)	United States	African American Women; White Women	Intersectionality; Pregnancy discrimination in employment—intersection with racial discrimination [63]
42	Small (2020)	United States	N/A	Marginalized groups representation hospital policy initiatives; COVID-19 [64]
43	Azhar et al. (2022)	United States	API Americans; White Americans	COVID-19 disparities—impact on Asian American and Pacific Islander communities; Anti-Asian xenophobia and COVID-19; Policy recommendations [65]
44	Thapa et al. (2021)	India, Nepal	Brahmins; Kshatriyas; Vaishyas; Dalits	Caste and health discrimination; Caste stigma; Economic inequality; Culture and beliefs [66]
45	Yengde (2022)	India, Nepal, United States	Brahmins; Dalits; African Americans; White Americans;	Global caste; Race and caste; Comparative analysis of global caste systems [12]
46	Narasimhan (2019)	South Asia, India	Ancestral North Indians; Ancestral South Indians	Ancient human migration in Eurasia; Spread of agriculture; Genetics and anthropology [11]
47	Mégret and Dutta (2022)	India, United States, United Kingdom	Brahmins; Dalits; Indian Diaspora	Anti-caste discrimination law; Casteism within Indian diaspora communities; Impact of global mobility on discrimination; Transnational caste discrimination [67]
48	Yelton et al. (2022)	United States	African Americans; White Americans	Depression; Social determinants of health; Socio-economic status and health; Education access and quality; Neighborhood and built Environment; Healthcare access and quality [68]

3.1. Health Disparities across Various Forms of Racism and Casteism

Race- and caste-based discrimination pose a significant threat to population health within the broad context of the World Health Organization's health definition. This issue manifests as structural racism or casteism, contributing to health disparities among marginalized groups. The various forms of racism or casteism can impact facets of health depending on the religious, cultural, social, and economic contexts in the countries or their regions. Our review focuses on health disparities in the United States and Canada in North America, and Nepal in South Asia. Below, we briefly outline the characteristics of health disparities across the primary forms of racism and casteism prevalent in these regions.

3.1.1. Health Disparities Impacting Black African Americans

Numerous studies have reported that racial discrimination against Black and African American people leads to health disparities in the United States [5,9,22,26,27,31]. In the 21st century, new challenges emerged, including mass incarceration and racial inequities, resulting in disparities in education, jobs, housing, and healthcare. Disparities in healthcare and health outcomes have been well documented at the individual level but are less known at the population level [9]. Some of the most striking patterns of health disparities reported as pertinent to structural racism can be specified. For instance, Black people have elevated rates of mental health conditions like anxiety and depression, and they experience a higher incidence of hypertension due to racism-induced chronic stress [35]. However, due to racial marginalization, Black people are less likely to seek out or receive medical care than White individuals [32,48]. In 1937, the Home Owners Loan Corporation (HOLC) developed a map of Philadelphia, deliberately ensuring that Black people were more likely to reside in the disadvantaged neighborhoods. Decades later, Black Philadelphians faced a five-times higher risk of being assaulted with a firearm compared to White residents [36]. Black people, despite their higher resilience and coping ability, especially for mental disorders, are reported to have greater rates of physical disease morbidity than White individuals [38].

Socio-economic status (SES) is generally deemed to play a prominent role in health disparities across populations [6]. However, it is crucial to note that controlling for SES and education does not fully eliminate these disparities. This is because the effects of racism extend beyond the standard measures of one's life prospects. The evidence indicates that Black and White Americans living with the same SES and with the same level of education have very different life experiences [52]. The "diminishing returns hypothesis", proposed by Farmer and Ferraro in the health context, suggests that the differences between Black and White people are most significant at the highest SES levels [48]. This phenomenon is attributed to the interaction effect of race with SES, mainly education, showing that racial inequity resulting in health disparities, such as in self-rated health, are most prominent at higher levels of SES.

3.1.2. Health Disparities Impacting Indigenous Peoples

Native Americans and Pacific Islanders in the United States and Aboriginal populations encompassing the First Nations, Inuit, and Metis peoples in Canada are Indigenous peoples who have a long history of experiencing colonial racial discrimination, including forced displacement, dispossession of land, cultural suppression or acculturations, cultural insensitivity, and stereotyping [23]. Due to colonialism, Aboriginal peoples in Canada are particularly vulnerable to racial inequities and face significant disparities in health status, morbidity and mortality, and healthcare access compared to the non-Aboriginal population, with increasing evidence of health system-level inequities that require redressing as routine aspects of healthcare [27,39].

3.1.3. Racism-Related Health Disparities Impacting Other Ethnic Groups

In the United States, Hispanic and Latino Americans, Asian Americans, Arab and Middle Eastern Americans, Jewish Americans, and other religion-specific minorities experience racial discrimination based on their languages, immigrant status, stereotyping,

and other historical biases, such as the Chinese Exclusion Act, Japanese internment during World War II, and anti-Semitic discrimination against Jews and the racial profiling of other groups [22,33]. In Canada, despite adopting the multiculturalism policy, the visible minorities comprising hundreds of ethnic nationalities face historical or immigration-related racial discrimination. Especially, Chinese and South Asians experience the painful memory of historical racial discrimination related to immigration (such as historical trauma due to the Chinese Immigration Act, 1885, known as the Chinese head tax and the Komagata Maru incident in 1914), while they continue to face structural discrimination, which was exacerbated during COVID-19 pandemic [69]. Chinese people were stigmatized for COVID-19 virus origin [70], and the South Asian population in British Columbia was increasingly associated with a higher exposure to confirmed COVID-19 infection because of their living circumstances [69]. All these forms of racial discrimination bring about intergenerational trauma and prejudices in employment or livelihood circumstances that result in chronic stressors, leading to disparities in both healthcare access and health outcomes.

3.1.4. Caste-Based Health Disparities and the Link between Casteism, Transnational Casteism, and Racism

In South Asia, particularly India and Nepal, the countries where the concept of caste originated, the traditional Hindu caste system, with its four hierarchically tiered caste groups- Brahmin, Kshatriyas, Vaishya, and Shudra, traditionally assigned by the individuals' birth, is the longest surviving system of social hierarchy and segregation that put people, especially those who are now called Dalits, at the lowest stratum of society by historically relegating them to a position of inferiority [67]. Recent anthropological and genomic research indicates that race and caste share common roots, stemming from the migration of Middle Eastern farmers and Great Steppe pastoralists to ancient India and Europe around 4000 years ago [10,11]. In ancient India, the patterns of accumulation and concentrations of the agricultural production surplus by the dominant groups evolved into a hierarchical caste system through the initial segregation of people into groups by the knowledge and occupational skills gained [10,11]. Eventually, it took a cultural and religious turn following the composition of the Hindu scriptures Rigveda and Manusmriti between 1200 and 1300 BCE [67].

A literature review of nine full articles conducted by Thapa et al. shows that individuals' opportunities to access education, employment, and healthcare are negatively impacted by caste discrimination [66]. Dalits experience negative health impacts to a significantly greater extent due to both their caste status and poverty, which put them at a higher vulnerability to health risks, along with the general denial of healthcare provisioning to discriminated segment of the population [66].

Transnational Casteism

The United States and Canada continue to deal with the existing problem of race-based discrimination, due to reinforced and embodied structural racism [22], as a domestic phenomenon. Mégret and Dutta, conducting a study from a legal perspective, shed light on the new phenomenon of transnational casteism in Western countries, which has emerged as the migration of discriminatory practices through diasporic dispersion [67]. The authors defined the phenomenon as "the continuation of patterns of discrimination exported from the society of its origin but manifesting themselves in a host country". The authors explained that, as casteism's discriminatory practice was largely unknown to the societal systems in the host countries, the growing incidents of caste discrimination are facing a wave of legal challenges.

Mégret and Dutta highlighted the challenges the host states have faced, in terms of their laws and policies, in resolving this emerging problem due to difficulties in addressing them through the existing discrimination legislation. The ability of the dominant sectors of the diaspora to deny the existence of caste practices abroad reflects its power to set the narrative [67]. The authors admitted that their frameworks of discrimination analysis

remained limited to the emphasis of the domestic context and its supranational supervision, which leads to a situation of neglecting the extent to which transnational discrimination has increased through the migration patterns of intra-diasporic discrimination. From their case study based on the Indian diaspora, the authors make recommendations for further study on the origin, nature, and impact of transnational casteism, which can potentially change the concept of how discrimination plays out as well as how the law can address the arbitration of cultural and political legacies from abroad to lend a voice to the discriminated groups among diasporas. Considering the impacts of caste discrimination on health disparities reported by the countries of origin, transnational casteism is bound to have implications on health disparities in the host countries that deserve a discourse yet to be documented.

3.2. Theoretical Underpinning

While structural racism as a determinant of health disparities in the United States and Canada is well documented as a complex issue [9], caste discrimination from South Asia, painted with cultural orientation despite its commonality with the former as global caste [12], adds a further layer of complexity to our discourse. Considerations of theoretical underpinning are, therefore, essential to provide a systematic, informed, and comprehensive approach to understanding and addressing such a complex issue for advancing our knowledge that can deepen interdisciplinary insights with repeatability for better predictive power. In the literature, we reviewed a few well-established theoretical and conceptual frameworks of racism (as applied to caste discrimination as well) that have been reported in relation to health disparities. We considered four major theories that directly relate to structural racism or casteism that have causal relationships with the production of health disparities at the societal or population level transcending through generations.

Two seminal theoretical and conceptual analyses of society-level health disparities in relation to race and ethnicity as their structural and systemic determinant have been well documented [9,71–73], namely Krieger's Ecosocial Theory [22] and Ford and Airhihenbuwa's explanation of critical race theory (CRT) from a public health perspective, which they refer to as public health critical race Praxis (PHCRP) [73] in the United States. Both guide the overarching contemporary worldview of structural racism and casteism, leading to both interpersonal- and population-level health disparities. To provide a concrete, feasible, and tenable approach to improving population health equity, Bailey et al. suggested a focus on structural racism, referring to "the totality of ways of societies fostering racial discrimination through mutually reinforcing systems of various living factors (such as housing, education, employment), which, in turn, reinforces the discriminatory behaviors and impacts on the distribution of resources" [9]. Furthermore, CRT, which was originally used in legal studies, is characterized by race consciousness and emphasizes contemporary societal dynamics and socially marginalized groups, as well as the praxis between research and practices [73]. Ford and Airhihenbuwa applied the CRT to shift the paradigm for analysis and interventions to eliminate structural racism [73]. It promotes health equity by responding to structural racism's contemporary influence on health, health inequities, and research. Both theories could be extended to the historical health disparities caused by the so-called cultural caste discrimination handed down for centuries in South Asia, as the proponents of both theories have already applied the frameworks to a wide range of racially disadvantaged ethnicities (e.g., Roma populations in eastern Europe).

Another two theories, historical trauma theory and fundamental cause theory, extend further by explaining the mechanisms of how health disparities as damaging impacts are produced in racially disadvantaged groups. Historical trauma theory posits that disadvantaged groups with a unique history of race-based adverse life trauma experience physical, psychological, and economic disparities that persist through generations [31,37,74]. The psycho-spiritual impacts of multiple traumatic events, such as forced relocation, forced assimilation and annihilation, termination, and discrimination transcending generations, have resulted in post-traumatic stress disorder (PTSD) in Native Americans [37]. Likewise, the experience of slavery, marginalization, discrimination, and systemic violence has caused

African Americans to experience poorer health compared to White individuals throughout their lifespans and has had cascading effects across generations, contributing to widespread health disparities [31]. On the other hand, Subica and Link outlined the fundamental cause theory, which posits that certain racial groups experience health disparities due to underlying socio-economic factors such as lower socio-economic status, stigma, and racism, restricting their ability to access health-protective resources [33]. The authors advocate applying the theory to any disadvantaged group, race, and ethnicity (or caste) in describing their health disparities resulting from an impact of cultural trauma, such as ongoing physical or psychological assault imposed on them by an oppressive dominant group usurping another group's cultural resources through force, threats of force, or oppressive policies [33]. However, the social factor in question must be able to impact multiple health outcomes in a population, embody access to flexible resources, and reinforce replaceable mechanisms over time, thus complying with structural racism or casteism.

Additionally, social cognitive theory posits a connection between one's knowledge and beliefs and one's actions and behaviors, indicating that evidence-based theoretical frameworks can be useful in assessing persistent genetic testing disparities among various populations. McKinney et al. used this theory to understand the psychological factors behind disparities in the use of genetic testing to detect cancer risks between White individuals and other racialized populations [40].

From an Indigenous population and public health perspective, structural discrimination has been understood as a major determinant of the distribution and outcomes of social and economic inequities, creating the conditions that sustain the proliferation of health disparities resulting from socio-economic inequities [27]. Defining structural discrimination as "structural violence", Browne et al. referred to "the disadvantage and suffering that stems from the creation and perpetuation of structures, policies, and institutional practices that are innately unjust, because systemic exclusion and disadvantage are built into everyday social patterns and institutional processes" [27].

3.3. Issues of Science

3.3.1. Genetic Variations

Genetic variations among human population groups are widely misunderstood due to the persistence of pseudo-scientific 17th-century theories that sought to divide populations into races or castes based on imagined biological differences. Nancy Krieger clearly described the stormy "state of contemporary discourse on race, genetics, and health disparities in the United States over whether race is a biological or social construct, and also whether racial/ethnic disparities in health are due to either innate genetic differences or the biological impact of present and past histories of racial discrimination and economic deprivation, or both" [60]. More recent scientific evidence has firmly established that stratification of humans by race or caste is an anthropogenic socio-cultural construct driven by the dominant group of humans leading to the socio-economic discrimination of marginalized groups and associated health disparities and does not hold a genetic basis to classify them as they are recognized in the society [67]. Basing "race" on skin color alone is not tenable because skin color is not linked to a specific gene unique to individual races or castes. Instead, the phenotype of skin color is the expression of myriad combinations of multiple genes [51]. Over time, natural selection retains phenotypic traits best suited to the environmental conditions in a certain geographic area. The genetic basis for caste formation handed down from ancient India, on the other hand, was claimed merely on the notion of "purity" maintained through endogamy, which was never full-proof. However, recent anthropological and genomic research showed that all caste groups of India are descendants from admixtures of three ancient ancestries—Indigenous ancestries of Dravidians and two transmigrant ancestries from Anatolia and Steppe mountains, forming ancestral genomic clusters of admixtures, namely Ancestral North Indians (ANIs) and Ancestral South Indians (ASIs), in a gradient of their varied proportions of these three ancestries across the Indian populations [11]. Further evidence indicates that the socially

identified categories of races comprise most genetic variations within, rather than between their populations [10,52], disproving the notion of a genetic basis for race or caste.

As the meaning, significance, and use of the race concept varied historically with economic, political, social, and cultural influences, some biomedical scientists may carry the belief that racial difference is biologically meaningful impacting on health differences across race and ethnicity groups [46]. This stems falsehood from the science and medicine of early modern era that harbored the mythological notion of biological race, such as claiming the existence of "Black" genes inherited by Black individuals, resulting in their race as inherently inferior to White people, implying that behavior and physical features are solely determined by genetic characteristics, with impacts on differences in disease occurrences [35,46]. For scientists and scholars who visualize race as a social construct, extant racial (or ethnic) categories can be used as a proxy for socio-cultural, economic, and historical processes and experiences to capture behavioral and structural differences between racialized groups [46,52]. Genetic variations do exist within and between given human populations, like in any organism. However, these variations do not conform to extant notions of racial categories and the associated racial health disparities [46]. The presence or absence of numerous genes makes the differences in the causation of common or complex diseases, and they also may contribute to disparities in the disease prevalence across population groups; however, from the science of genetics, it is well understood that the causation of a disease is a result of a complicated process of interaction between genes and the environment [47].

Sankar et al. suggested that overemphasizing the contribution of genetics to the causation of health disparities could be misleading and even reinforce racial stereotyping, as considerable evidence exists indicating that health disparities resulted in the United States largely from "long-standing, pervasive racial and ethnic discrimination", rather than genetical effects [47]. More recently, Martinez et al. also suggested that narrowly focusing on genetic variations undermines the complexity of interactions across biological and structural factors in the risk of causation of diseases such as atopic diseases, including asthma [29]. Most human diseases, such as diabetes and hypertension, are polygenic and occur in association with a host of genetic risk factors, environmental risk factors, and social determinants of health, rather than being tagged to a race or caste group [49]. A few relatively rare diseases, like sickle cell disease associated with the HbS allele commonly reported among Black people and Tay–Sachs disease and thalassemia, commonly reported in the Ashkenazi Jew community, are the results of gene mutations that occur under conditions of certain environmental exposures, originating from the malaria endemic regions, for a long time [52]. Such diseases are inheritable diseases, as a single gene controls them. However, they are not inherently associated with the overall genomic composition of any race or ethnic group, rather with historical exposure by the way of carriers of mutated genes, leading to the vulnerability of the people of a socially constructed race or ethnicity.

3.3.2. Genetic Testing

The science of genetics sheds light on the existential realities of humanity. However, because of the incomprehensive and biased usage of scientific knowledge in the past, genetics was taken for granted to support and justify the discrimination, criminalization, and institutionalization of individuals or groups of people categorized as belonging to certain races [40]. These historical injustices have created a mistrust in medical research, fear of discrimination and abuse, and reduced access to services like genetic counseling, leading to persistent disparities in the uptake of genetic services, such as genetic testing in the United States [42]. Distrust among racialized communities continues to be a barrier to their use of genetic testing. However, evidence-based guidelines promoting genetic testing are increasingly available in some clinical settings [42].

3.3.3. Epigenetic Changes

Martin et al. clarified that race is not biological; rather, it is a social construct used to organize people into a social hierarchy based on physical or imagined features [59]. They also highlighted the importance of epigenetics, an emerging area of science that examines the DNA methylation (DNAm) of genes, including those responsible for stress and inflammation in response to adverse social environments in early life. Social epigenetics can shed light on the biological pathways by which social experiences affect health outcomes, providing us with a plausible biological mechanism for health inequalities [31,59].

The intergenerational health consequences of historical trauma experienced among Holocaust survivors and Indigenous populations are well documented [31]. The findings from the research evidence suggested that historical intergenerational trauma caused by adversity, such as racial discrimination, can affect gene expression, resulting in biological dysfunction through epigenetic alterations. Such adversity affects the immune, neuroendocrine, and cardiovascular systems, leading to epigenetic aging via the methylation of immune response and threat-related amygdala reactivity genes [31]. Such epigenetic changes include exposure to racial discrimination associated with lower parasympathetic cardiac modulation as measured by heart rate variability [31] and the low birth weight of babies resulting from an alteration in the DNAm associated with fetal malnutrition [37]. Sweeting et al. highlighted that experiences of adversity, such as the impact of racial discrimination during pregnancy, can contribute to behaviors in the offspring as epigenetic changes have an impact in future generations and that these changes are associated with greater adiposity and body mass index in the offspring [31]. We posit that, at the societal level, such epigenetic impacts can cumulatively result in the behaviors or disproportionate health outcomes across populations, contributing to structural health disparities.

3.3.4. Psychosocial Stresses, Allostatic Load, and Telomere Shortening

Various chronic psychosocial stresses, such as cultural trauma and social disadvantages caused by pervasive racial or caste discrimination, are found well documented [31,33]. Subica and Link emphasized the significant impact of cultural trauma from racial discrimination on affected groups, leading to social disadvantage, which can pervasively mediate psychosocial effects, ultimately resulting in mental and physical health disparities [33]. Parra-Cardona et al., Soled et al., and Keyes highlighted the consistent and independent association of chronic stress caused by racial discrimination with various health conditions, including anxiety, depression, hypertension, and physical disease [35,38,41]. Farmer and Ferraro, highlighting equity theory, suggested that feelings of unfairness resulting from racial discrimination can lead to psychological distress, which, in turn, negatively affects the physical and mental health of the affected people [48]. Jacoby et al. shed light on the challenges faced by Black and Latino communities living in disadvantaged urban environments that are exposed to the physical, social, and psychological consequences of violent crimes and injuries, which further exacerbate the negative impacts on their health and well-being [36]. Likewise, the Native American population faces a multitude of chronic stressors, including political oppression, intergenerational trauma, and socio-economic disparities that, in turn, influence behaviors in diet and physical activity, stress levels, and coping skills, contributing to adverse health outcomes such as diabetes [37]. Specific to caste discrimination in Nepal, an ethnographic study conducted by Kohrt et al. identified various mediators associated with caste discrimination, resulting in mental health disparities among caste groups [56]. The authors posit that stressful life events, low resource ownership, low household income, and a lack of social support are mediators that are significantly associated with health disparities.

Bailey et al. highlighted that the growing body of scientific evidence shows the association of experiences of racial discrimination at the interpersonal level with evident biomarkers of disease and wellbeing [9]. These markers include a higher allostatic load, inflammation, coronary artery calcification, dysregulation in cortisol, greater oxidative stress, and shorter telomere length [9,28]. The repeated activation of stress response systems

triggered by the exposure to various chronic stresses based on racial or caste discrimination can produce an "allostatic load," which is the "cumulative biological burden" to adapt to the demands for life's survival and maintenance [44,52]. In other words, exposure to chronic stresses followed by the repeated activation of the stress response systems overuses stress responses and makes them weak, resulting in an allostatic load as a compensatory measure that is the "weathering" or "wear and tear" in the body. In this process, because of neuronal axis and hormonal dysfunctions, a loss of cortisol's anti-inflammatory effects ensues an increase in inflammation and oxidative stress, which, in turn, pose an elevated risk of cardiovascular, immune, and metabolic dysfunctions [44]. Consequently, a high allostatic load negatively affects health. It is associated with increased hypertension, heart disease, increased risk of preterm birth and low birth weight, and poor self-reported health, potentially leading to the intergenerational consequences of health impacts as reviewed by Kaplan [52]. For instance, Black Americans suffer from chronic stress throughout their life and intergenerationally on an ongoing basis, ultimately resulting in their early deaths or higher mean allostatic load scores compared to those of White individuals [44,52].

Telomeres, the regions of repetitive DNA sequences that cap the end of a chromosome for stability, shorten as people age. They shorten with cell division due to oxidative stress breaking the DNA sequence. Geronimus et al. noted that oxidative stress, a biomarker measured using the telomere length, is an important mechanism linking aging, psychosocial stress, biological stress activation, inflammation, and disease development [44]. Geronimus et al. reported that middle-aged African American women have shorter telomeres than White women, and this difference was significantly associated with exposure to stressors [44]. For instance, Black women aged 49–55 years are biologically older than their White counterparts by an difference of 7.5 years, with the former's telomeres being 371 base pairs shorter than the latter's. Stress and poverty account for 27% of this disparity. This was attributed to the fact that Black women are forced to adapt to repeated material, psychosocial, and environmental stressors throughout their lifetimes.

3.4. Social Determinants of Health and Structural Determinants of Health Disparities

Social determinants of health (SDoHs), the non-medical social and economic factors or circumstances people face in life, overwhelmingly impact our lives and behavior and outweigh all other factors (known as risk factors). Therefore, reducing health inequalities depends on reducing socio-economic and other inequalities [75]. The 2008 WHO Conceptual Framework for Action on Social Determinants of Health (WHO CSDH) looked at the social determinants of health to explore the root cause of disparities and develop actionable opportunities for addressing health disparities [30,75], while the conventional aggregate classes may even be deemed by some scholars no longer important as a determinant of health in modern society [34]. Many reviewed studies were agreed on several of these individual social determinants, such as race, employment, housing, income, education, and healthcare [47,50]. More recent studies have explained that there are mutually reinforcing inequitable systems in these social determinants of health, such as housing, education, employment, income, healthcare, criminal justice, and so on, which, in turn, reinforce discriminatory beliefs, values, and the distribution of resources that altogether lead to the risk of health disparities [9], acting together or interacting with each other [28,30,33,35], e.g., interactions between Black race and education, income, and occupation [48], resulting in health disparities at the population level. As the socio-economic position determines the education level, household income, assets, or employment [59], Soled et al. further put forward that inequitable morbidity and mortality, exacerbated during the COVID-19 pandemic across racial groups in the US, showed how historical racism expressed in healthcare, housing, employment, and education has continued to have an impact on society [35]. It was also demonstrated that health benefits result from initiatives to improve household income, education, employment opportunities, housing, and neighborhood conditions [28].

There is a consistent agreement among the studies in our review that racism and casteism need to be considered as structural determinants of health disparities among his-

torically marginalized populations, specifically Black people and Native Americans in the United States, Indigenous peoples in Canada and Australia, and Dalits in Nepal [9,27,30,59,66]. Health disparities cannot be simply attributed to behavioral or cultural factors; "rather, they are embodied manifestations of the complex interplay of socio-historical, political, and economic determinants of health" [23,39]. Examining a host of disciplines and sectors, including medicine, public health, housing, and human resources in the US context, Bailey et al. posited that structural racism has a substantial role in how the distributions of the various social determinants of health are played out with respect to the population health [9]. According to these authors, structural racism refers to "the totality of ways in which societies foster racial discrimination through mutually reinforcing systems of housing, education, employment, earnings, benefits, credit, media, healthcare, and criminal justice" [9].

Understanding the structural nature of racism and its impact on health, accounting for the impact of historical factors such as intergenerational trauma, we can observe how the multiple outcomes from its redress can have ripple effects. For example, Gee and Ford explained how the 1964 Civil Rights Act, which prohibited employment discrimination, changed the demographics of healthcare as more People of Color entered medical school and nursing school and went on to serve previously underserved communities [26]. Diaz et al. portrayed a framework of structural and social determinants of health contributing to the racial and ethnic-based disparities in healthcare access or outcomes in the United States, cutting across the healthcare continuum during the COVID-19 pandemic, when all the manifestations of unintended or untoward consequences were exacerbated universally, and also proposed potential areas for required action [30].

3.5. Discussion of Major Issues in the Review

Historically, racism and casteism have occurred based on supposed race or caste differences, by descent, between dominant groups, such as White individuals in the US and Canada and the so-called higher castes in Nepal, and marginalized groups, such as Black and Native Americans in the US, Indigenous peoples in Canada, and Dalits in Nepal. Both concepts have a common root and consistent characteristics, confirming Wilkerson's integrated idea of global caste [12,14]. The literature reviewed in our study supports the consensus that structural racism and casteism are major determinants of health disparities.

Krieger's ecosocial theory and Ford and Airhihenbuwa's extension of the CRT through a public health perspective (i.e., PHCRP) provide solid foundations for explaining racism or casteism as structural determinants of health disparities at the population level [22,73], while other researchers often view critical discussions on this topic as unwarranted [23]. There exists no ambiguity in the fact that the color blindness or caste blindness of egalitarianism cannot fully address the persistent systemic bias or disadvantages that appears in a wide range of socio-cultural norms or practices, anything from subtle bias to grave harms (e.g., incidents of rape or killing of people), which could occur even when the perpetrators do not always realize that their wrongdoings are unacceptable deeds tantamount to a crime against humanity in the 21st century.

The body of literature reviewed in our study is buttressed by the prior literature on the structural nature of racism and casteism and the implications for health inequities. Disparities in health outcomes are created systemically or structurally as the complex consequences of long-standing historical racial or caste discrimination, mediated through the commonly known SDoHs, passing through various stages from chronic stresses to genetic, epigenetic, physio-pathological changes that disproportionately cause morbidity and mortality among racialized populations. Based on both the fundamental cause theory and historical trauma theory [31,33,37,74], we can infer from the scientific evidence available in the 21st century that the table has turned upside down, as "the victim-blaming game", with the false claims of eugenics imposing the idea of racially marginalized people inheriting inferior genes or biological characteristics, is over; instead, the blame is now

being redirected to the dominant groups, or the state in most cases, as the perpetrators are responsible and accountable for causing harm in a structural manner.

The body of 21st century's scientific knowledge has gained a consensus which, from the findings of our review, can be summarized as follows: (1) genetic variations can naturally occur between and within population groups for various reasons beyond socially constructed races or castes [29,52]; (2) genetic testing can be a useful means of improving the health of the populations provided their use is not prejudiced or stigmatized across socially constructed races or castes [40,42]; (3) epigenetic changes occur due to the intergenerational trauma and harm caused by structural racism [31,37]; and (4) continuous exposure to chronic psychosocial stressors for a long period of time can cause an "allostatic load" on the discriminated people, resulting in disproportionate rates of health outcomes and explaining the mechanism of pervasive structural health disparities across populations [31,33,56].

Diaz et al.'s examination of the COVID-19 pandemic to visualize the profound health disparities caused by structural and social determinants, such as racism, shed light on the determinants contributing to health disparities from a holistic perspective, and also provided the opportunity to recognize areas of action [30]. Clearly, the individual social determinants documented in this US study can serve as proxies of racism, acting as fragmented parts of the whole structural determinants of health disparities that cross-cut across the healthcare continuum or also perhaps at the upstream population level [30]. This indicates the potential that the manifestations of racism could have occurred with any combinations of all those social determinants at any stage of the healthcare continuum in a variety of complex scenarios, mediating the overall impacts of structural disparities, depending upon the various untoward circumstances and challenges faced by the marginalized people. The conceptual framework of upstream and proximal pathways of structural racism and its health impacts, adapted by Martinez et al. from the earlier work of other researchers, convincingly shows how racism and other discriminations, including casteism, act as structural determinants of health disparities and trigger various determinants of health to mediate through various pathways, leading to biological embedding (e.g., psychosocial and physiological stresses, adaptive immune responses, etc.) and resulting in racial disparity outcomes, such as allergy and immune functioning [29]. The authors further explained that these pathways demonstrate the mechanism of biologic embedding.

Vervoort et al. explained that Indigenous peoples in Canada was at a higher risk of cardiovascular disease compared to non-Indigenous people, with multiple associated factors, such as historical oppression, racism, healthcare biases, etc. [58] These findings were consistent with the structural violence suggested by Browne et al., who posited that racism and discrimination must be considered determinants of health for Indigenous peoples [27]. Likewise, Thapa et al. explicitly posited that caste is a fundamental determinant of social exclusion and development, impacting commonly known determinants of health, such as education, employment, income, and housing [66].

Overall, addressing structural determinants of health disparities may require targeting cultural trauma through policy changes or direct interventions for a way forward in rectifying historical injustices through reparative policy or intervention programs that are race-conscious rather than race-blind [33,35].

3.6. Limitations of This Review

Our study was implemented with a short timeline for the completion of extraction, consolidation, and synthesis of cross-disciplinary knowledge as the beginning to provide a global perspective on racial and caste discrimination as a structural determinant of health disparities. We might have also missed a vast wealth of literature from India, though we made efforts to include Nepal as a less studied jurisdiction of caste discrimination as mandated by the PI's research program, especially in relation with health disparities. For that reason, the search terms were analyzed to extract the essence of knowledge from our targeted interests, rather than making this paper an exhaustive treatise in the vast areas of

multiple disciplines from health sciences to social sciences. We see this as a limitation of our study that can be expanded in future studies along the lines of this research.

3.7. Reparative Policy Considerations

Several of our selected reviewed articles have discussed the implications of research that could inform policy formation or suggested interventions through policy changes towards eliminating health disparities rooted in structural racism or casteism. A set of recommended reparative policy changes for research and interventions extracted from the reviewed articles is presented in Table 2.

Table 2. Major areas of reparative policy changes recommended for the elimination of structural health disparities associated with racism and/or casteism, based on the reviewed articles.

Areas of Reparative Policy Changes	Recommended Example Domains Based on the Reviews
1. Advancement and funding availability in health disparity research	• Explicit definition and relevance of race and ethnicity in health disparity research [46]. • Enhancing the investigation of the relationship between structural racism and population health outcomes [9]. • Research on social determinants of rare diseases' health disparity [45]. • Community-driven research to develop a holistic, culturally safe, and ethically appropriate health system to improve the health of all Indigenous peoples in Canada [58]. • Research on problematic institutional practices, discourse, and taken-for-granted norms that permit racism and casteism pervasively in healthcare systems [23]. • Rigorous longitudinal research on the impacts of parental preconception adversity [31]. • Further genomic studies in South Asia could add knowledge of complexity in the genetic composition of its population [11]. • Genetic research on health disparity-related conditions, such as heart disease, diabetes, and asthma [47]. • Health disparity analysis including a focus on micro-ethnic groups (MEGs) for a more fine-tuned level of race and ethnic considerations [51]. • Participation of diverse populations in genetic research and testing to provide opportunities for healthcare delivery and the eradication of health disparities [53]. • Cross-disciplinary validation of evidence that can lead to social epigenetics having clinical, policy, or therapeutic impacts [59]. • Research on the multiple dimensions of structural racism as the fundamental cause of health disparities [26].
2. Development of organizational structures, programs, and processes for reparative policies to support health equity	• Developing policies to rectify past injustices of specific populations as well as remedy current inequitable outcomes [35]; • Fostering health equity in partnership with Indigenous peoples in foundational policy changes [27] and in response to minoritized groups for culturally and linguistically appropriate services [43]; • Programs of interventions to improve household income, education, and employment situation as well as neighborhood conditions that have demonstrated health benefits [28]. • Active participation of the medical and research community in policy reform, advocacy, community redevelopment, and place-based partnerships [29]. • Developing global human rights policy to eradicate caste discrimination and health disparities mediated by poverty, lack of social support, and stressful life events [56] and including caste discrimination in the United Nations Sustainable Development Goals (SDGs) agenda [66].

Table 2. *Cont.*

Areas of Reparative Policy Changes	Recommended Example Domains Based on the Reviews
3. Advancing racial justice in population health	• Youth well-being through environmental, economic, housing, educational, criminal justice system, child welfare, and health policies [32]. • Understanding stress factors for decreasing the allostatic load among Native Americans [37]. • Emphasis on evidence-based interventions based on systematic surveillance to address racial disparities in the criminal justice system and public health domains [57]. • Youth well-being through environmental, economic, housing, educational, criminal justice system, child welfare and health policies [32]; • Understanding stress factors for decreasing allostatic load among Native Americans [37];
4. Addressing targeted cultural trauma for the restoration of damaged cultural modes	• Racial socialization, community mobilization and capacity building, and raising awareness among dominant groups [33].
5. Ensuring an equitable healthcare system for all	• Addressing racial stereotypes and stigma surrounding substance use and poverty [39]. • Patient-centered health interventions, education, and promotion efforts that are responsive to ethnocultural factors [50].
6. Addressing genetic discriminations	• Addressing concerns about potential genetic discriminations in various contexts, such as life insurance [42]. • Development of interventions for genetic counseling, increasing genetic testing awareness [40], and policies such as Americans with Disabilities Act (ADA), 1990, which prohibits discrimination based on health status encompassing most genetic conditions [60].

Many of the reviewed articles have focused on research gaps in supporting evidence-based policy changes leading to interventions [23,26,28,31,46,53,58], while Bailey et al. even suggested that the health impacts of policy changes and interventions with potential for dismantling structural racism have been less studied [9]. The US NIH's 1994 "inclusion mandate" brought women and minorities into clinical research; however, the operationalization of "race" and/or "ethnicity" was not explicit in 82% of the research articles reviewed by Lee [46]. Williams suggested that the US Health Disparity Research and Development Act was relevant to future research for rare disease policy development [28], while Powell-Young and Spruill posited that the diverse populations' participation in genetic research would lead to improving healthcare for the elimination of health disparities [53]. Gee and Ford recommended more studies on disparities, especially considering the multiple dimensions of structural racism as fundamental causes of health disparities [26]. Browne even showed the urgency of research to develop effective interventions for disrupting problematic processes to provide care to stigmatized people [23]. Vervoort et al. suggested that community-driven research would help us to better understand the gaps in holistic cardiovascular care so that healthcare and systems interventions could be made culturally safe and ethically appropriate for Indigenous peoples in Canada [58]. Sweeting et al. pointed out the need for funding for "rigorous longitudinal research", especially among African Americans, for examining the negative health impacts of "intergenerational transmission of trauma", such as the impact of parental preconception adversity on offspring that could lead to public health interventions [31].

Mental health is profoundly reported in the literature as one of the main areas of policy implications owing to the structural nature of the extant health disparities linked to

racism or casteism, especially among African American youths [32], Indigenous peoples of Canada and Native Americans [37,39], and Dalits in Nepal [56]. A few selected articles described policy implications for understanding stress factors in the Native American population [37]; targeted interventions to reduce caste-based disparities in mental health, such as in rural Nepal; addressing poverty, lack of social support, and stressful life events [56]; and advancing mental health with racial/social justice [32].

Genetic discrimination has been historically a major issue of racism that led to the false claim of biological differences among races, as described in the preceding section. In the 21st century, policy reform is needed to address concerns among patients, research participants, and other stakeholders, including healthcare providers, especially about potential genetic discrimination in US life insurance and for the development of guides for genetic counseling to serve as an intervention to address causal genetic beliefs [40,42]. Longitudinal studies are needed for formulating effective interventions to reduce health disparities through building evidence of the primary biological mechanism of DNAm, providing social epigenetics knowledge that has clinical, policy, and therapeutic implications [59]. Immigration policy is another area of structural racism, since the US's exclusionary immigration policy uses racial groups to reinforce social hierarchy, resulting in disparate health impacts [26]. Williams et al. posited that anti-immigrant policies adversely affect population health, creating hostility towards immigrants and leading to their vulnerability [28]. Other areas of policy implications that were drawn from the selected reviewed articles include policy considerations for "geographically identified micro-ethnic groups for more nuanced and sensitive level analysis than race" [51], to address health disparities through a patient-centered approach encompassing outreach and capacity-building efforts [50], and to emphasize interventions based on the evidence from systemic surveillance of key criminal justice-related events that have health impacts [57].

4. Conclusions

In this cross-disciplinary review of the literature from the 21st century, it has become evident that race and caste stem from a shared socio-cultural construct dating back to ancient times. Both have common characteristics, including dominant groups oppressing vulnerable groups in society to ensure the dominant groups' own socio-cultural and economic advantage in terms of power, privilege, and resources. Racism and casteism evolved and flourished, especially during the colonization period of the 17th century onwards, reaching the egregious levels of slavery and dehumanizing discrimination, such as segregation and untouchability. While the 21st century has witnessed strides in socio-political development, rising awareness and aligning it with human rights' worldview and progressively achieving social change, there are many challenges to overcome the structural nature of racism and casteism that are the structural determinant of health disparities across populations. Accordingly, pseudo-scientific genetic discrimination, the epigenetic effects of intergenerational trauma, disproportionate rates of various disease conditions caused by "allostatic load" (e.g., diabetes, hypertension, and mental health setbacks), and lingering social stigma are still extant, with several risk factors and social determinants of health acting as mediators. Structural- and societal-level health disparities were consistently reported in all three case study countries, the US, Canada, and Nepal.

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